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CEDRAT TECHNOLOGIES IN PICSAT CUBESAT TO HELP UNRAVEL MYSTERIES OF YOUNG STAR SYSTEM

PicSat, a 3U CubeSat satellite, developed in record time by a small team of scientists and technicians at the Paris Observatory in France, is about to unravel the mysteries of a young star system in the solar neighbourhood.

PicSat carries a Cedrat Technologies piezo stage XY400M that is a crucial element of the payload. The stage generates two perpendicular translations of 400 µm thanks to four APA400M actuators. Moreover the actuators are fitted with strain gauges sensors to control the displacements.

PicSat is designed to observe the bright star Beta-Pictoris, the second star of the constellation Pictor, or Painter's Easel, seen from the Southern Hemisphere. In orbit around Earth at a height of 600 km, twice that of the International Space Station, **PicSat** will be able to look at the star continuously, unhindered by the Earth's atmosphere or the cycle of day and night.

Beta-Pictoris is a unique star system in that it is, astronomically speaking, very young (about 23 million years), it has an equally young planet, it has a very massive disk of debris of gas and dust, it is seen edge-on, and it is close to the Sun at just 63.4 light years. This means it is easy to observe and allows astronomers to learn more about the very early stages of planet formation and planetary disk evolution.

A POSSIBLE TRANSIT OF BETA-PICTORIS B

A few years ago, it became clear that the Beta-Pictoris b Hill Sphere (or gravitational sphere of influence), or perhaps the planet itself, will be passing in front of its star as seen from the Earth. The detailed observation of such a phenomenon would allow learning more about the young planet. However, the moment of transit can only be estimated roughly, because the orbit of Beta-Pictoris b is not that well known. The transit has been predicted to occur between the summer of 2017 and the summer of 2018. The transit of the planet would only last for up to a few hours. A transit of the Hill Sphere could last for several month.

During a transit the amount of the light that reaches us from the star is slightly diminished while the planet is blocking out a small part of it. This little dip in the star's brightness can be captured by a sensitive instrument, a photometer that accurately measures the light from the star collected by a telescope. In order to capture the phenomenon, continuous accurate monitoring of the star system from Space is the only possible way. **The main science goal** of PicSat is exactly that: observing the brightness of the star Beta-Pictoris continuously, so as to capture the small dip in the light of the star as the planet Beta-Pictoris b or its Hill Sphere passes in front of it.

THE PICSAT PROJECT

PicSat has been developed by a small team at the LESIA laboratory of the Paris Observatory and the PSL Université Paris, led by Dr. Sylvestre Lacour.

Figure 1: CubeSat with the PicSat team

PicSat is one of the few cubesats worldwide with an astrophysical science goal, and the **first cubesat** in the challenging field of **exoplanetary science**.

PICSAT TECHSPECS

PicSat consists of three cubic units. The top and middle cubic units hold the satellite's payload, the bottom unit contains the onboard computer.

The **top cubic unit** of PicSat contains a small telescope, with a five centimeters diameter mirror. Thanks to the fact that Beta-Pictoris is such a bright star, this small mirror size is sufficient to collect enough light from the star.

An **important innovative technical aspect** of the PicSat satellite lies in the **middle cubic unit**. A **tiny optical fibre**, three micrometers in diameter, collects the light from the star. Used frequently at Earth based observatories, it will be the **first time** that an optical fibre is flown in space for astronomical observations. The telescope system in the top unit sends the light of the star onto its focal plane at the bottom of the unit and into the fibre. The tiny fibre collects the light and sends it into a sensitive photodiode in the middle unit that accurately measures the arrival time of each photon individually. The advantage of using an optical fibre is that due its small size, it eliminates all disturbing light sources from entering the photodiode, and thus makes a very accurate measurement of the star's brightness possible. These are for example stray light from the sky and scattered light within the optical system.

Figure 2: XY400M CTEC product mounted on PicSat

The pointing accuracy of a CubeSat is not sufficient to allow the telescope to send the light from the star exactly into the small opening of the fibre all the time. The telescope will move too much as a result of jitter of the satellite. The PicSat team devised an innovative solution for this problem by connecting the optical fibre to a piezo stage, provided by Cedrat Technologies. The piezo stages allows to move the fibre in circles around the star at 100 Hz. As soon as the star moves away from the centre of the fiber, a 100Hz modulated signal is produced, which allows the programming behind the piezo stage to track and re-centre on the star, and remain on target. This technology is new and if it proves successful, it will allow new developments for the use of fibre optics on space based platforms.

PICSAT LAUNCH, ORBIT AND COMMUNICATION

PicSat was launched on 12 January 2018 on an Indian rocket, called a Polar Satellite Launch Vehicle (PSLV), developed by the Indian Space Research Organisation (IRSO), together with several tens of other cubesats and a bigger satellite.

The final orbit of PicSat is a polar orbit, at an height of 600 km above the surface of the Earth. This means that PicSat will orbit over the poles as the Earth rotates below it, which will allow PicSat to stay on Beta-Pictoris continuously. Each orbit will take 90 minutes to complete.

In orbit, PicSat is operated from the PicSat Ground Station at the Paris Observatory in Meudon, France.

The PicSat website (*picsat.obspm.fr*) display up-to-date lightcurve of the star, the brightness of the star as a function of time, as measured by the payload. PicSat is foreseen to operate during one year.

PICSAT SUPPORTING INSTITUTIONS

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USEFUL ONLINE RESOURCES

PicSat **website** (containing many references):
picsat.obspm.fr

Cedrat Technologies **website**:
cedrat-technologies.com